U.S. DEPARTMENT OF ENERGY
SOLAR DECATHLON
2011

Uncovering Myths and Opportunities of Advanced Building Envelope Technologies: BIPV, Roofing and Windows

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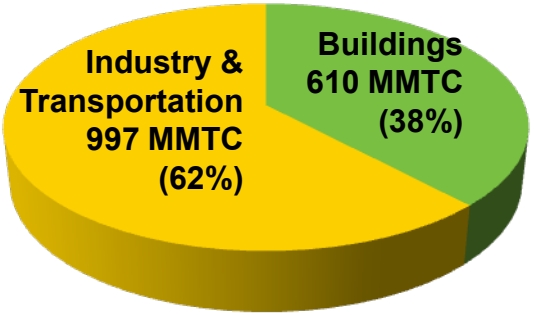
Outline

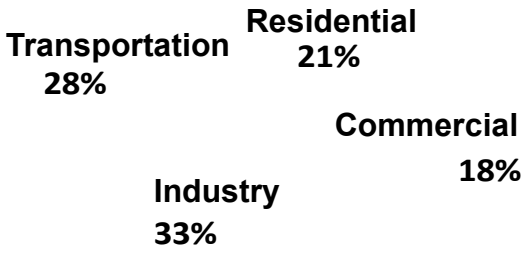
- Building's Energy and Environment Impacts
- Windows
- Roofs and Walls
- BIPV – Building Integrated Photovoltaic Cells

US Building Energy Use and Carbon Emissions

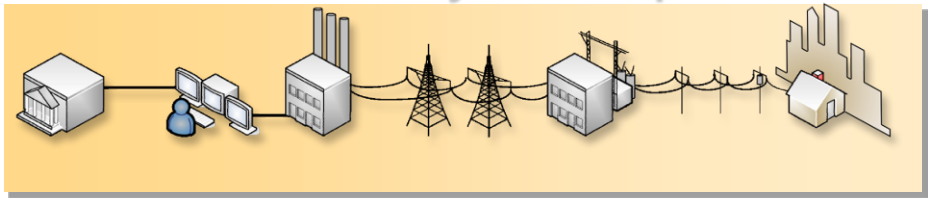
38% of U.S. Carbon Emissions



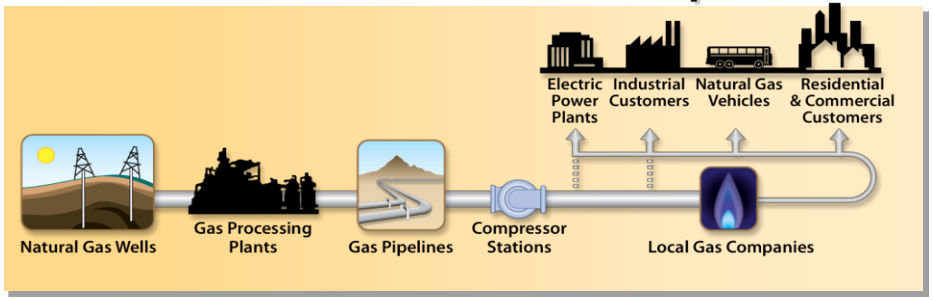
39% of U.S. Primary Energy Consumption



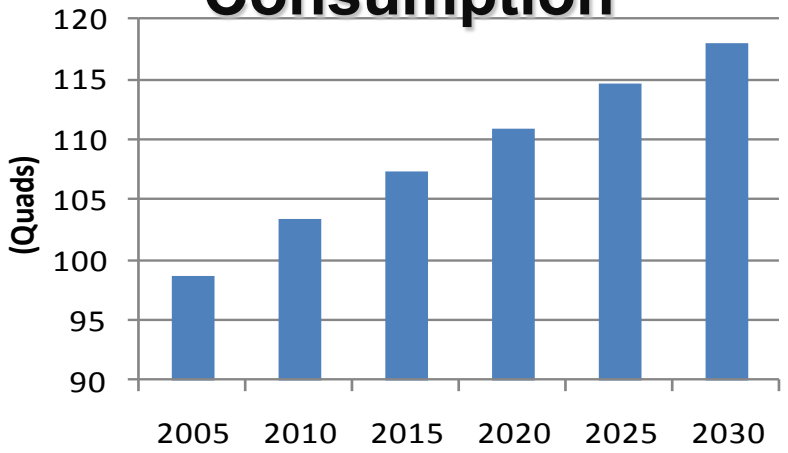
72% of U.S. Electricity Consumption



54% of U.S. Natural Gas Consumption

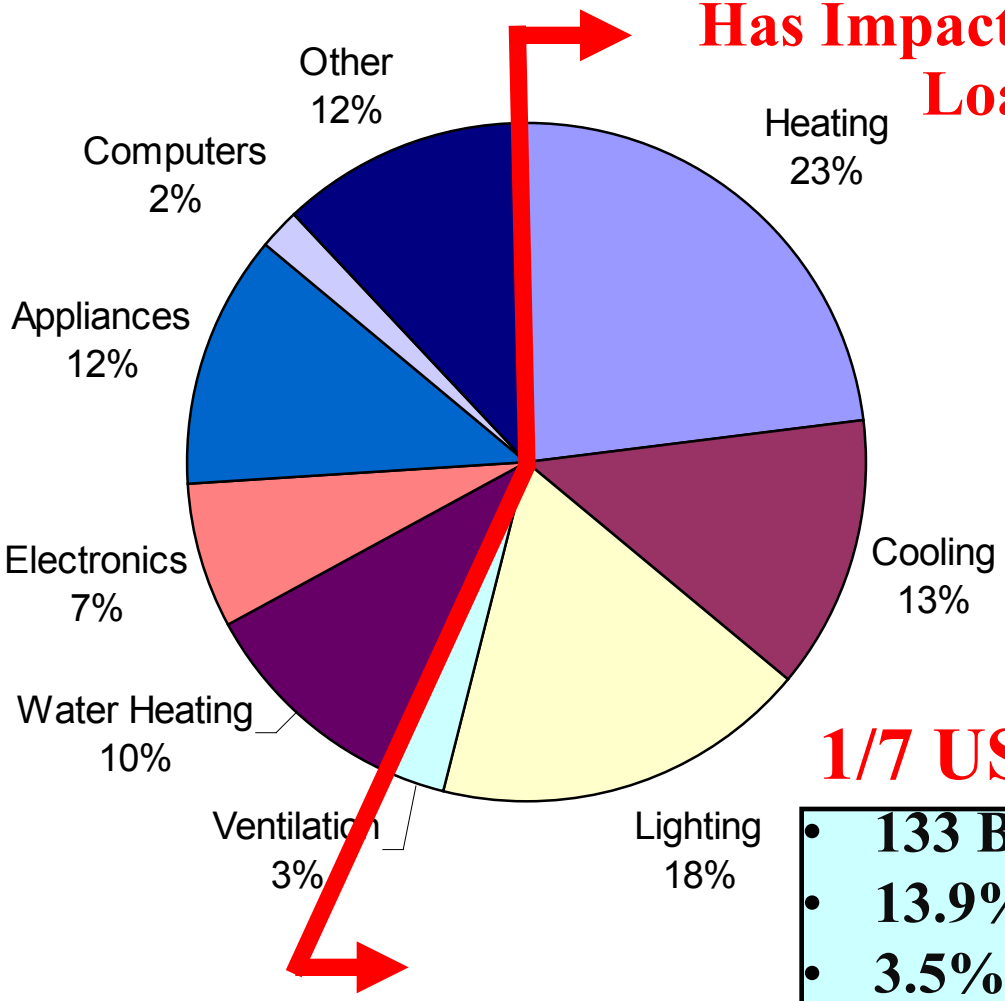


Total U.S. Energy Consumption



Sources: BED 2009; AEO 2010

Building Consumption – Envelope Relationship



Has Impact on 57% of Loads

1/7 US Economy

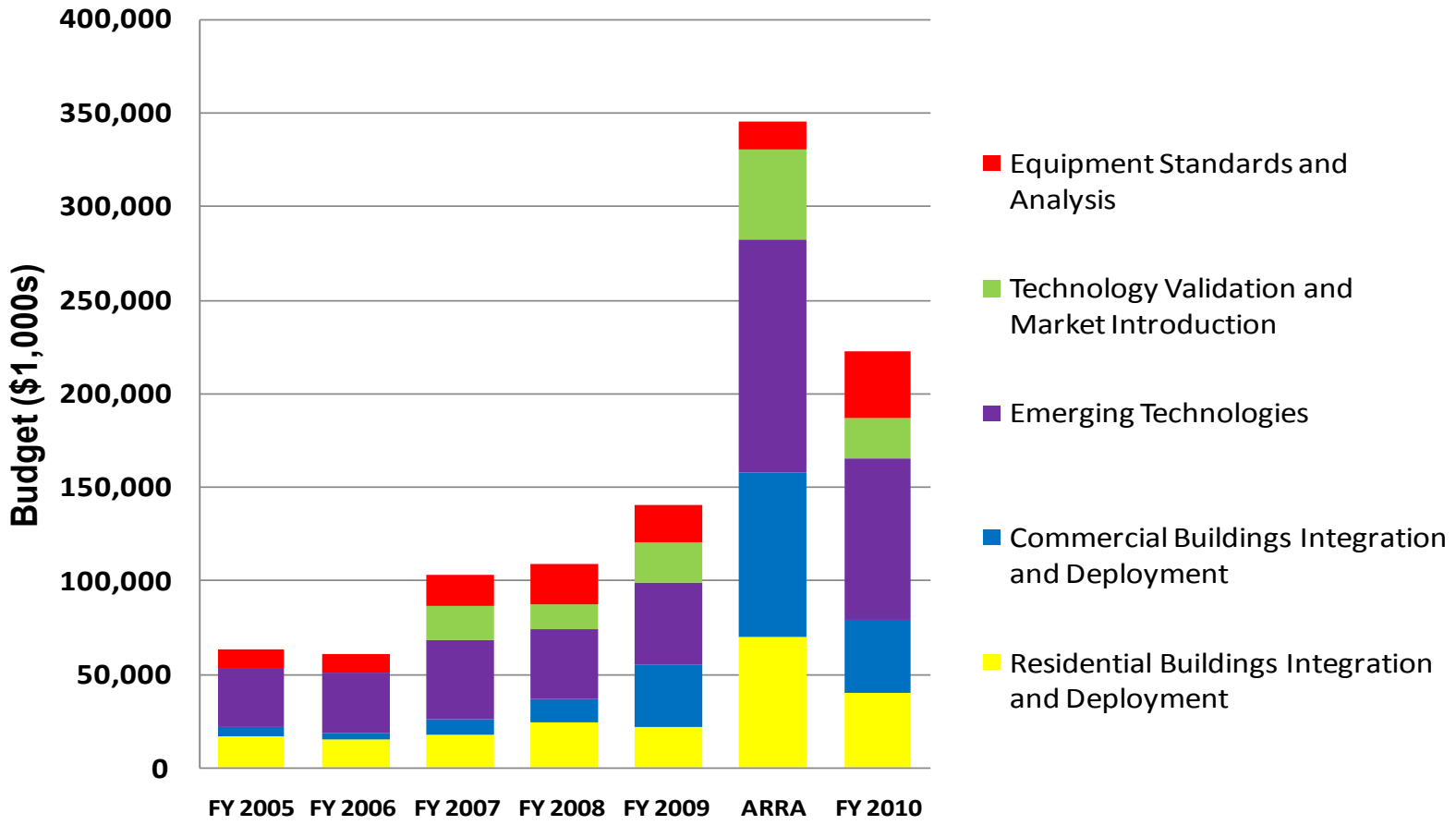
- **133 Billion $/yr**
- **13.9% US Energy**
- **3.5% Global Energy**

Capacity from Buildings for Transportation

Advanced envelopes save electricity and natural gas to free up capacity for bridging fuels.

Budget History

BTP Funding ~ 220M → US Building Energy Expenditures ~ 450B

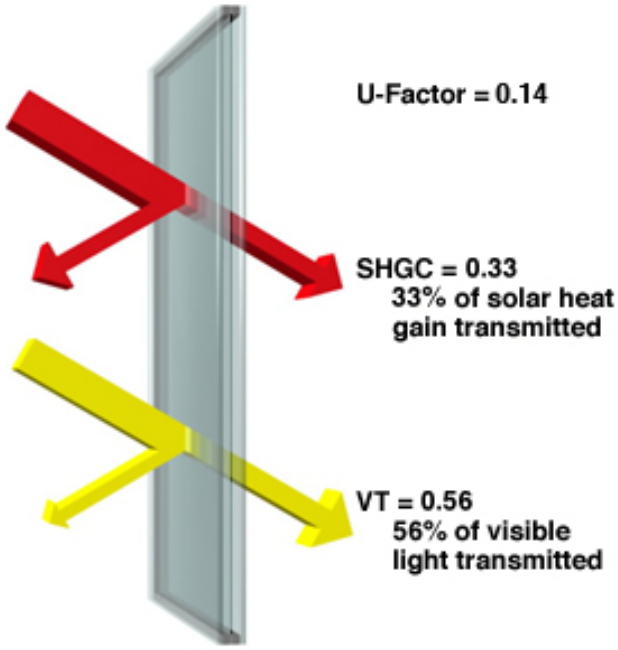


Source: U.S. DOE

Energy Metrics for Windows

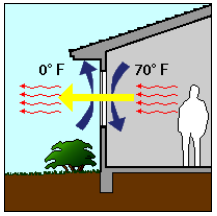
- Key performance indices
  - U-factor
    - Thermal resistance
    - Units Btu/hr-ft2-F
    - R-value is inverse, U=0.5, R=1/0.5 = 2 hr-ft2-F/Btu

    (Example U=1, R=1; U=0.2, R=5)
  - SHGC
    - Solar Gains
    - Ranges from 0-1, higher means more solar gains
  - VT
    - Visible Transmittance
    - Ranges from 0-1, higher means more daylight

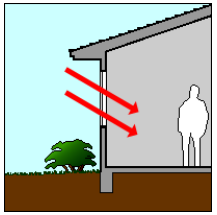


NFRC Window Energy Ratings

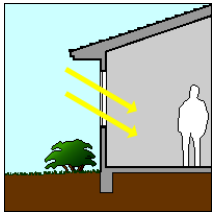
NFRC = National Fenestration Rating Council



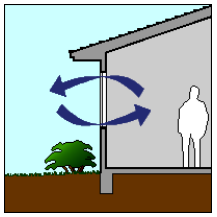
U-factor
Lower = less heat loss



Solar Heat Gain Coefficient (SHGC)
Ratio of solar heat gain



Visible Transmittance (VT)
Higher = more daylight



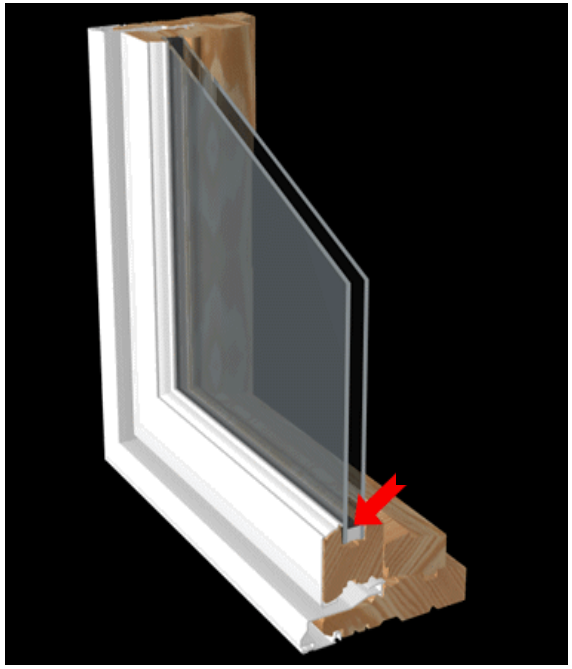
Air Leakage (AL)
Higher = more infiltration

NFRC ratings: aggregated performance of whole window, including

- frame material
- glass
- gas fill
- spacers

What type of window do you have in your home? Major progress since the energy crisis of the 70's

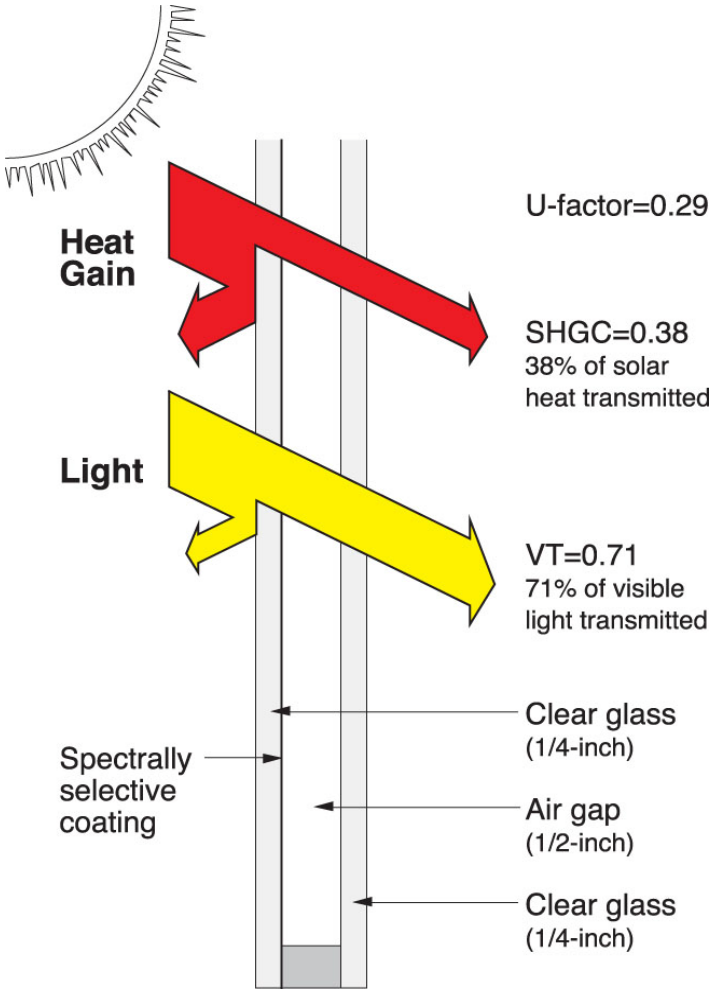
- 1973: Typical Window:
  - clear, single glazed,
  - double or storm window in north,
  - **$U_{average}$ = .85 BTU/hr-F-sq.ft.**



- 2002: Typical Window:
  - 95% double glazed
  - 50% have a low-E coating
  - 30-65% energy savings vs. 1973
  - **$U_{average}$ = .45 BTU/hr-F-sq.ft.**

Achievements: The Low-E Success Story

- Transparent metal coating
  - Reflects heat back inside in winter
  - Reflects solar heat out in summer
  - Allows day light
- Reduces window energy by 30-65%.
- Very low cost
- Wide spread technology (60 to 70% of residential window sales)
- Main attribute of code compliant windows
- Still needed for advanced windows



Window Myth - Opportunity

- Homeowners always want new windows for efficiency – damaged window seals (fogged), difficult to open, aesthetics, resale value, etc
- Energy Auditors – Windows are never cost effective
- With new technology and competitive prices – advanced windows can now be cost effective from an energy efficiency retrofit perspective (almost always cost effective if you will replace for non-energy reasons)
- R5 windows now with prices premiums below $4 per sq ft
- Low e storm windows (durable low e, can be exposed to the environment) cost about less than half of code compliant windows but provide comparable performance (best suited for low income and historical applications)
- Consider high performance windows, at least buy ENERGY STAR windows
- For consumer window education and economic details see **www.efficientwindows.org**

Volume Purchase Program

Windows and Low-E Storm Windows Specifications and Certifications

High Performance Windows

- U-factor: 0.20-0.22
- Air leakage: ≤ 0.30 cfm/ft^2
- Certifications: NFRC/NAFS
- Warranty (yr): 20 glass/10 non-glass
- NFRC label required
- NAFS 05: Performance Grade R25

Low-e Storm Windows

- Emissivity: <0.22
- Structural test: ANSI/AAMA 1002.10-93
- Registry: IGDB (LBNL database)
- Warranty (yr): 10 glass/non-glass

Find Vendors to Purchase (min order 15/20)
www.windowsvolumepurchase.org

Window Film Retrofit Applications - energy, blast, hurricane, etc.

Look for new NFRC ratings

Working on other attachment ratings – shades, etc

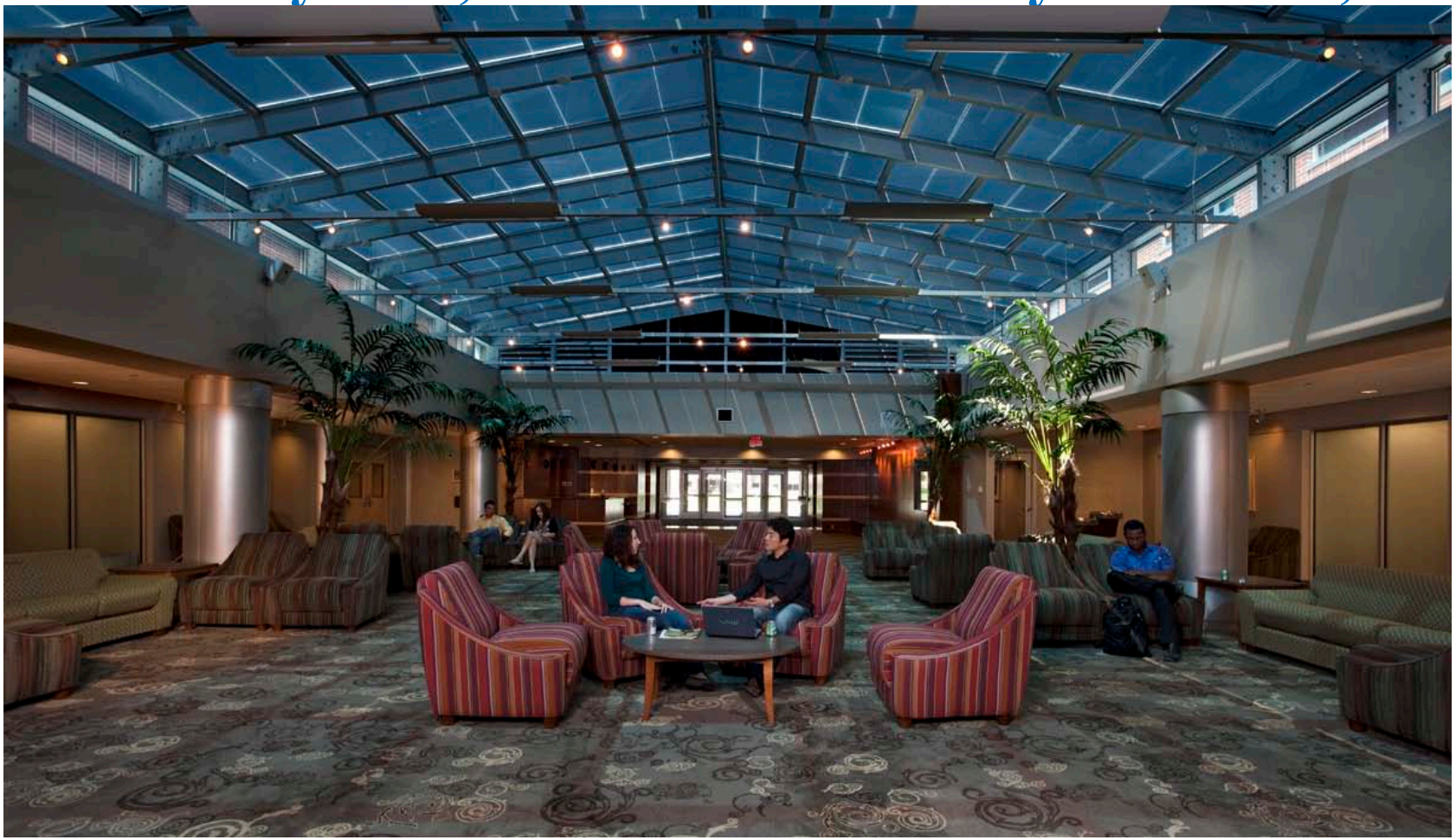
Next Generation of Windows

- Highly Insulating
  - Goal U value 0.10 (SI U value 0.56)
  - Possible vacuum glazings
  - Provides system benefits, smaller HVAC, shorter ducts
- Dynamic solar control
  - Passive heating and dramatic peak cooling reduction, SHGC 0.53 – 0.09
  - Market ready, prices will drop with more investment
  - Many new projects underway, competitive market in 2012 - 2014

Prototype – Concept Window
(Highly Insulating and Dynamic
U Value 0.18 (SI U value 1.0)
SHGC 0.04 – 0.34)
Low cost unsealed center lite

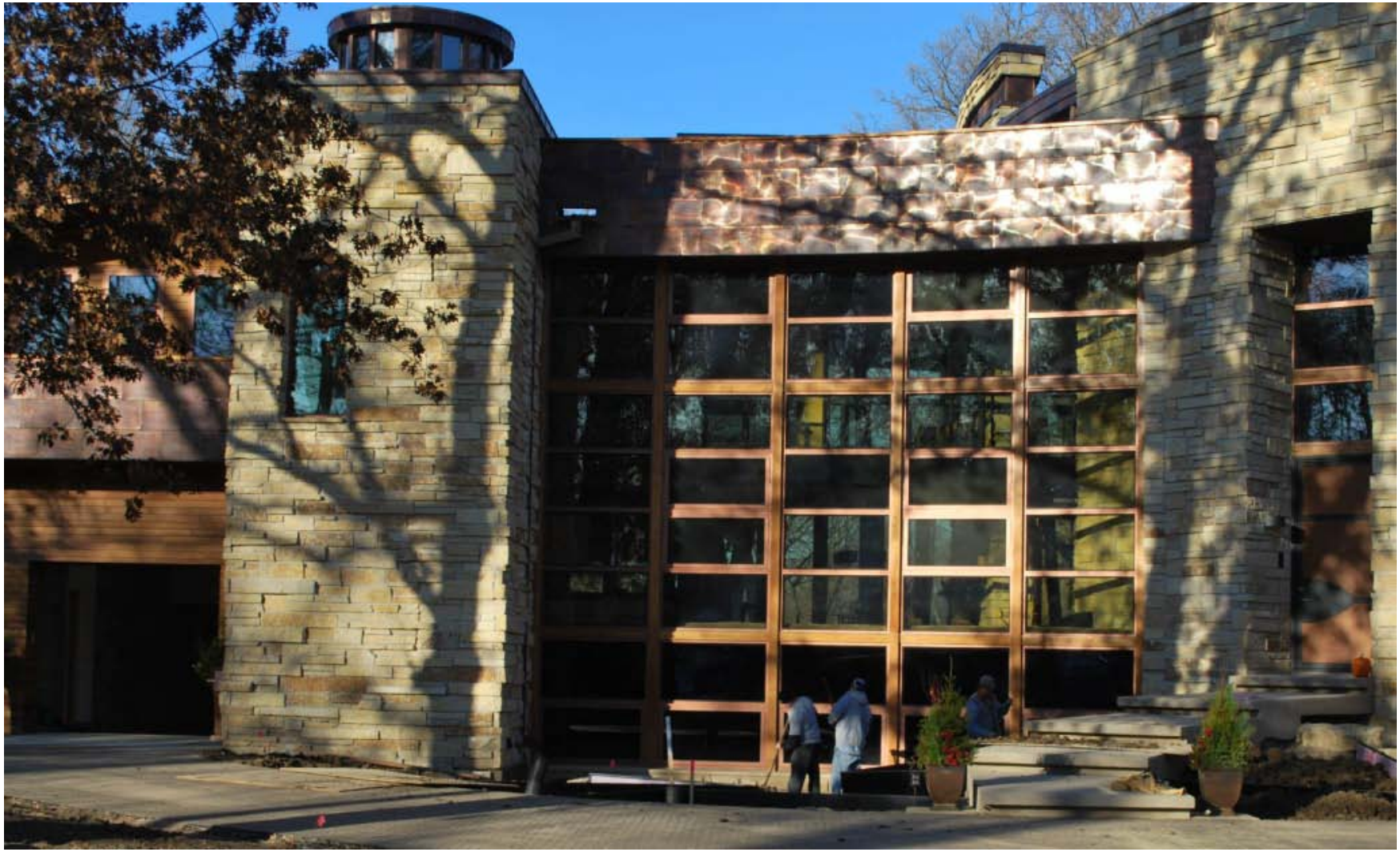
Dynamic Windows – Cost Neutral within 5 Years

DeHority Hall, Ball State University - Muncie, IN



Courtesy of Sage

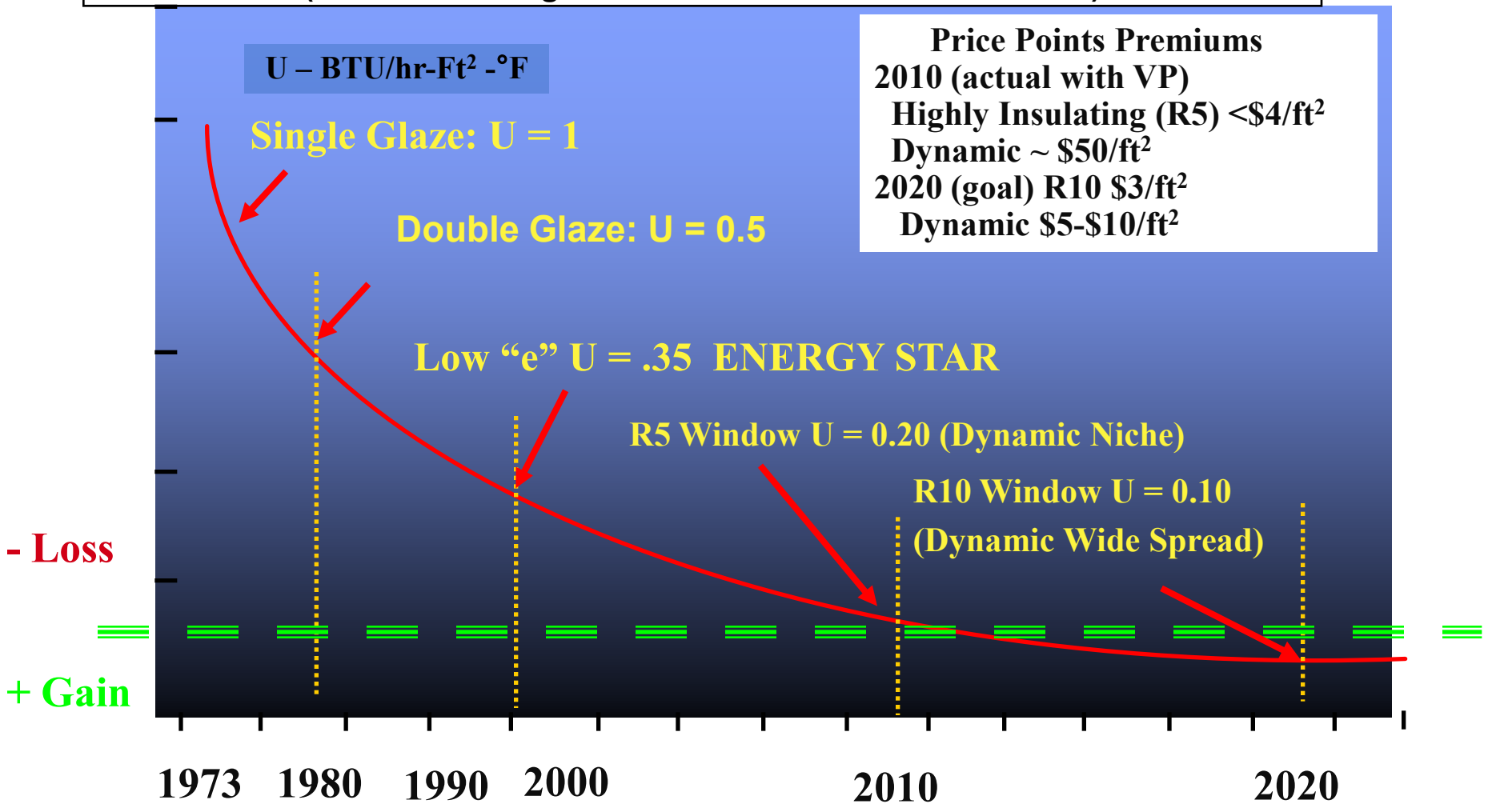
Highly Insulating Dynamic Window in 2010



South facing large residential home in MN – Courtesy Sage Electrochromics

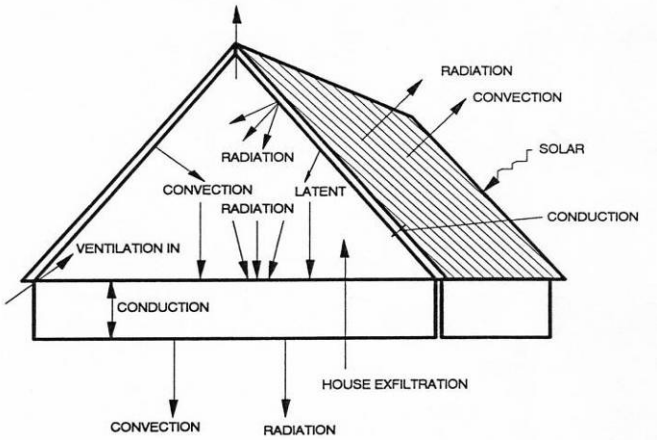
Advanced Windows Can Become Energy Producers

(Passive Heating from Mixed and Northern Climates)



Thermal Envelope R&D Roofs and Walls

- Advanced walls to reach R20 in 3.5” cavity, exterior insulation systems, R30 total wall
- Next Generation of Attic/Roof System to save 50 Percent Energy
- New Material Development
  - 100 R&D Award in 2009 for phase change insulation
  - Higher performing foams and aerogels
  - Dynamic membranes
  - Advanced cool roofs



Insulation–Infiltration (air leaks) Key Areas of Focus

Insulation Fact Sheet with Zip Code Calculator

How much insulation do you have in your attic?

DOE/CE-0180
2008

Department of Energy
Assistant Secretary
Energy Efficiency and Renewable Energy

http://www.ornl.gov/sci/roofs+walls/insulation/ins_01.html
http://www.ornl.gov/~roofs/Zip/ZipHome.html

Wall Retrofits

- Variety of cavity fill options for older homes without any insulation
- Exterior siding revitalization – Exterior Insulation Finishing Systems (EIFS) validated for moisture tolerance in comprehensive study – install with drainage plane
- Install board insulation beneath new wall cladding (siding)
- Interior insulation – aerogel with drywall offer high thermal resistance within a small space (R10/inch), expensive but with labor savings can be cost effective
- Reflective coatings for hot climates (near infrared pigment added to paint reflects the heat of the sun while offering many colors, white is always best)

Low Air Infiltration is Good – But Caution is Needed if Fossil Fuel Appliances are Used

- New construction – very low air infiltration, control fresh ventilation air and provide make up air (separate source of air) for fossil fuel appliances
- Retrofit – all electric house, can tighten ceiling plane (penetrations in your ceiling, wires, utility boxes, fans, fire alarms, wall interfaces, duct s, pipes, etc) without concern for safety prior to insulating attic and sealing ducts if you have them
- Whole house air sealing may require fresh air ventilation, not usually a problem in older homes
- For homes with fossil fuel appliances – need to provide fresh make up air or conduct detailed test with blower door (check for negative pressure and back drafting of appliances, combustion pollutants in home)

Myth – Blower Door Test is Always Needed

http://www.buildingscience.com/index_html

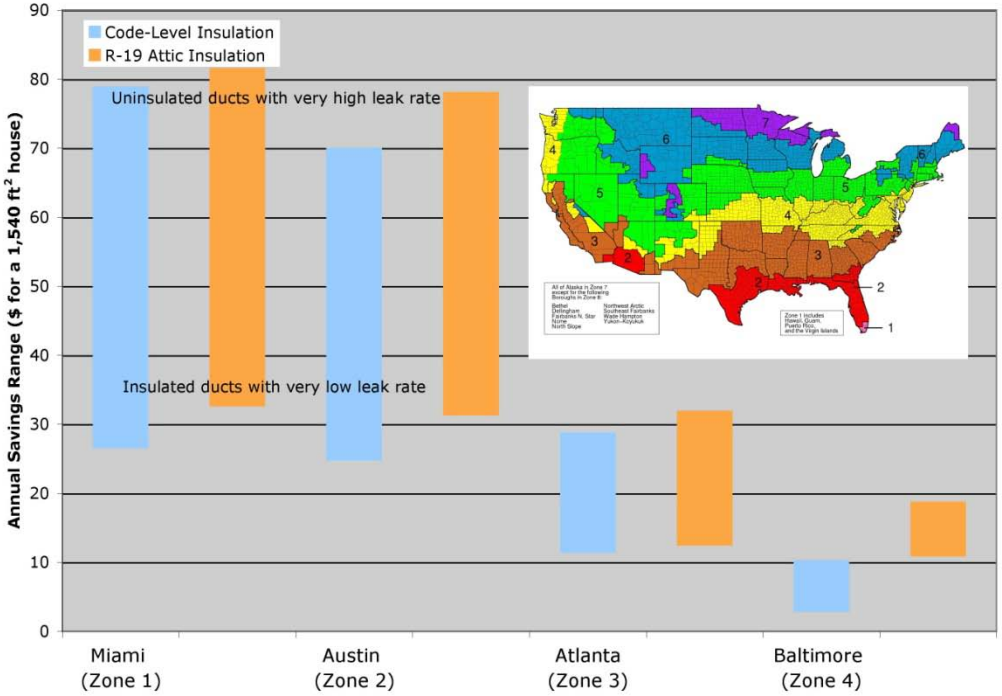
Search "Attic Air Sealing Guide and Details"

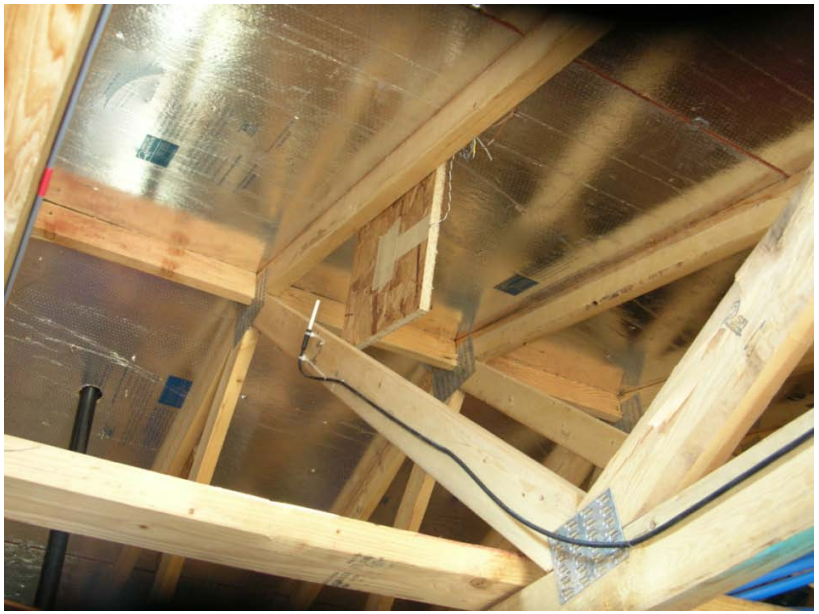
Conducting In-depth Air Barrier Research

- Sophisticated energy performance measurements
- Supports real world performance and code activity
- 20 wall panels with 13 manufacturing supplier partners and Syracuse Univ.
- Needed to support higher code levels leading to ZEB

Radiant Barrier – Fact Sheet (most cost effective for new construction in hot climates)

Radiant Barrier Advice: experiments and model

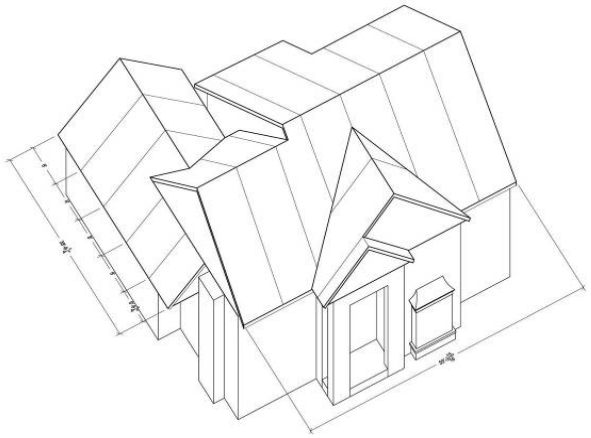




http://www.ornl.gov/sci/ees/etsd/btric/RadiantBarrier/

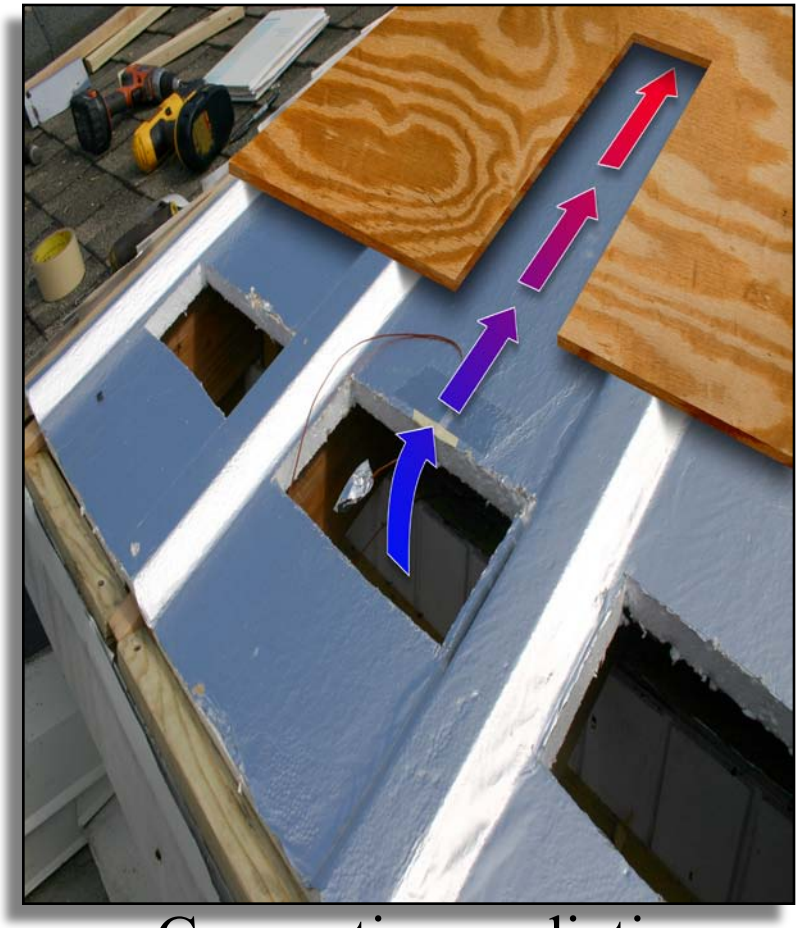
Next Generation of Roofing/Attics

- Integrated solutions for building type and climate
- Key elements to develop and integrate
  - Cool Roofs (lighter colors and near-infrared (NIR) reflective pigments)
  - Thermal Mass
  - Above Deck Ventilation
  - Radiant Barriers
  - Location and Higher Performing Insulations

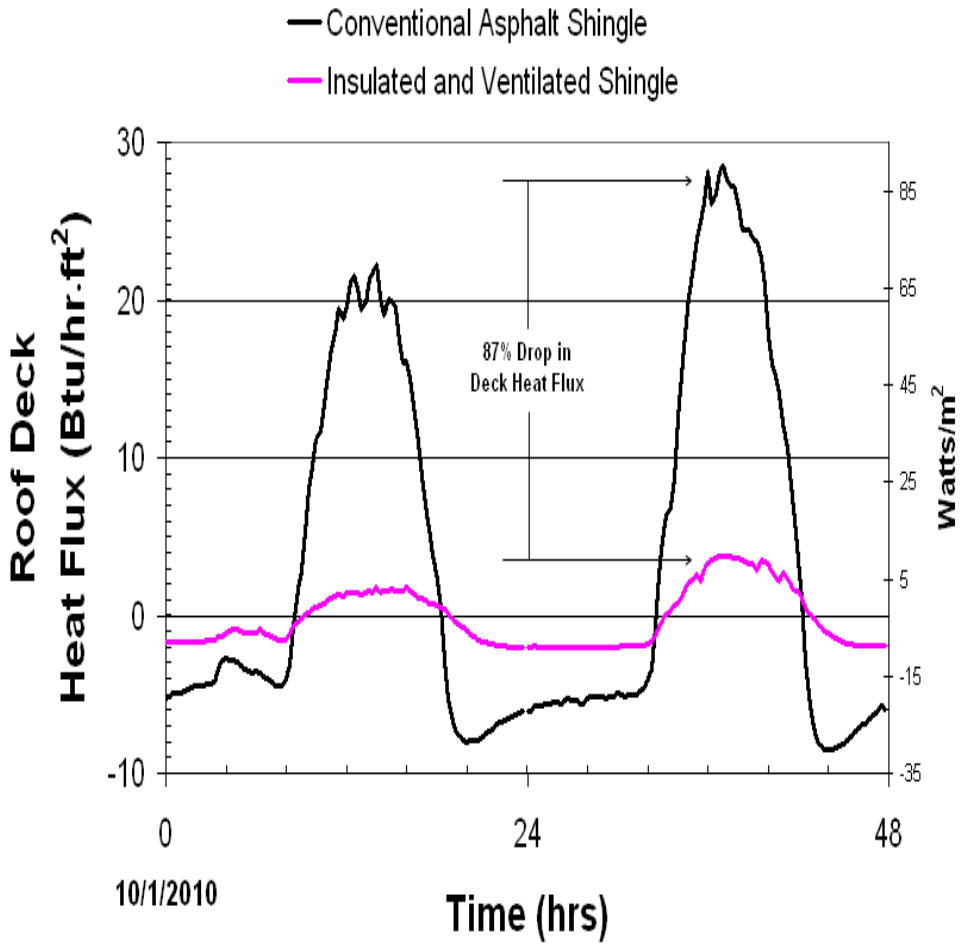


Above Deck Insulation and Ventilation

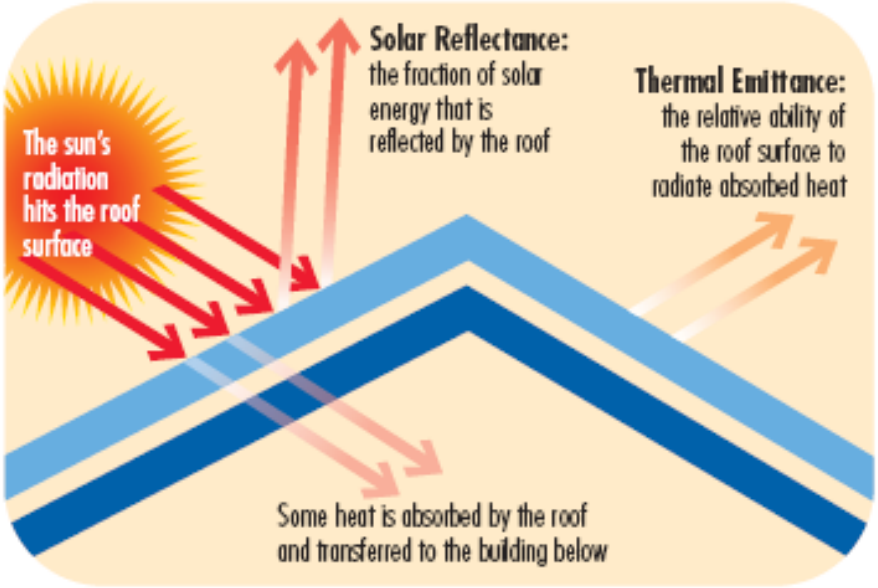
Retrofit: Incremental cost $1 per square ft; Payback ≤ 15 years

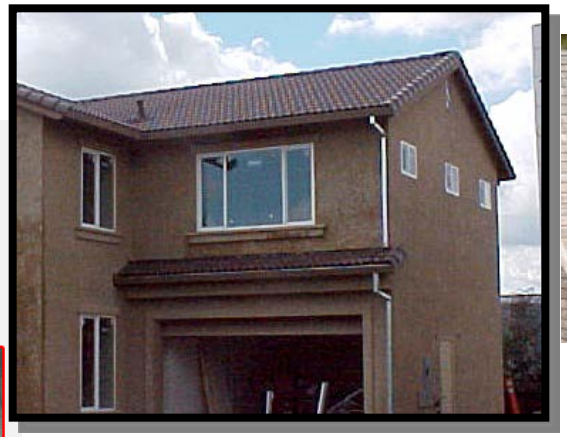


Convection, radiation and conduction controls



Cool Roofs, Green Roofs, and Photovoltaic Roofs





Future for Roofing – Cool Roofs, Green Roofs, and Photovoltaic (PV) Roofs

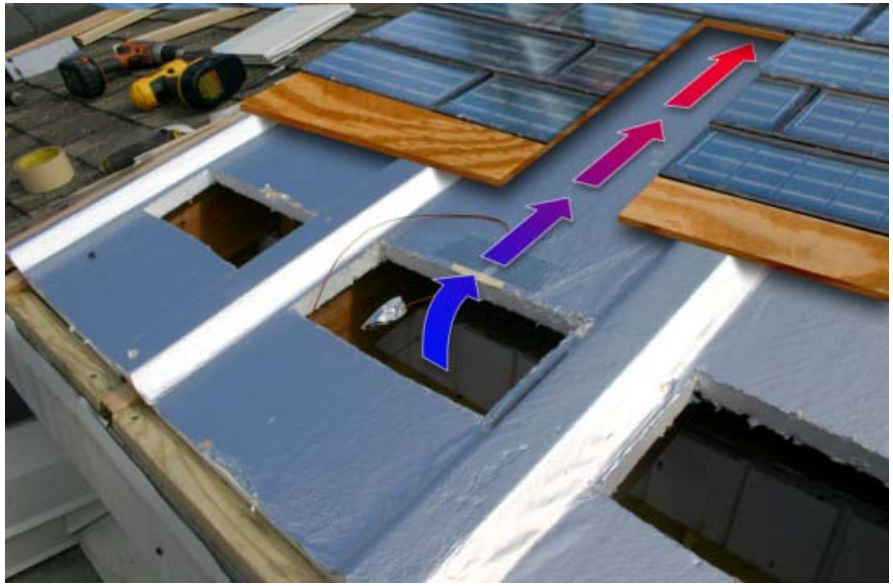
- All advanced roofs have their place and no need to compete – just provide improved information to ensure adequate assessments are considered
- DOE has extensive data and tools for cool roofs but mostly cost effective for commercial roofs – some applications in hot climates for steep slope roofs with mechanical systems and ducts in attics – R&D underway to deliver more cost effective products
- Green roofs – mostly for low-slope (flat roofs) with non-energy benefits, storm water run off, enjoyment of environment, etc
- New research shows large potential for global cooling, only “reflective roofs” provide benefit, not green or PV roofs
- PV is becoming more prevalent and on a path for cost effectiveness without subsidies in coming years

Building Integrated Photovoltaic (BIPV) vs PV Panel

- Aesthetically more pleasing
- Lower performance, lower cost
- Potential to be very easy to install
- Increases cooling load on building

- Shades roof and reduces cooling loads
- Higher performance and higher cost
- Concerns about roof interfaces, need to follow certified installation procedures

BIPV and Advanced Attic Roof System Integration



- Convert 10 to 30 percent energy penalty increase into load reduction decrease of 25 to 40 percent
- Reduce operating temperature of BIPV to increase PV output
- Provides comprehensive roofing solution
- Studies just beginning

Myth – Choose PV or a Energy Efficient Roof

Final Remarks

- Building Envelope has numerous opportunities for new construction and for retrofit
- New technology will be essential to achieve low carbon, low energy buildings
- Advanced roofing, cool roofs, and PV are compatible, all solutions will be needed for decades
- The need to continue with technology development, education, and dissemination will be essential to achieve large energy savings and environmental benefits
- Yesterday's myths can become tomorrows opportunities

Contact Information

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KEY ENVELOPE WEB PAGE

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